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VFL Testing of Detector Voltage as it Relates to Interference Detection

The DataMaster DMT is an infrared breath testing device designed to identify and quantify ethanol on the breath of individuals. It works on the basis of infrared absorption at specific wavelengths unique to ethanol. The DMT employs a Lead Selenide IR detector which is a photoconductive device that has sensitivity to IR in approximately the 2 to 5 micron range. The detector produces an output current proportional to the amount of IR energy incident on its surface. There are three filters within the DMT which filter the IR energy into specific and narrow regions. Those filters are centered at 3.44, 3.37 and 3.50 microns. These wavelengths allow for characterization of the absorption peak of ethanol in the 3.4 micron range where it has strong absorption of IR energy. The ratios between these three filters are unique to ethanol.

The detector voltage of the DMT is the DC output voltage of the detector processing circuitry. The voltage is typically viewed with the 3.44 micron filter (filter 1) in the optical path. When switching between the three filters, the detector voltage usually changes, though it is possible that there may be no difference in the reported voltages. The differences, if seen, are not due to the different wavelengths of the filters, but rather are due to the different characteristics of each filter's peak transmittance, half peak bandwidth and other variations of the transmittance characteristics of the individual filters.

The DC output voltage level of the detector ("detector voltage") is dependent on a number of conditions including detector sensitivity, IR source intensity, bias voltage level applied to the lead selenide, temperature of the detector as determined by the thermoelectric cooler, efficiency of the optical path through which the IR energy is transmitted (sample chamber), the peak transmittance and bandwidth of the IR filters and gain and offsets of the electronics processing the detector output current.

During instrument setup, a technician will adjust the parameters of the bias voltage level, TEC cooler level and IR source intensity per manufacturer's specifications such that the output DC voltage of the detector circuit is near zero volts when the 3.44 micron filter is in the optical path. Changes in the system components over time may cause the detector voltage to change from its original set value. Because of this, a zero baseline is established for each of the three wavelengths during the ambient zeroing process as part of every test sequence. A zero baseline is established for each of the three wavelengths as the voltage produced when each of the filters is inserted into the optical path is unique, as stated above. The DMT will zero the voltage so long as it is no more than approximately 1.500 volts, positive or negative, away from zero. If the voltage is within the allowable range for zeroing, the

process will go forward. If the voltage starting point is too far away from zero, the DMT will halt the test and produce an error message indicating that a filter will not zero.

The particular voltage level of the detector output has no bearing on the DMT's design or ability to identify interfering compounds in a breath or simulator sample. Interference detection is based on the ratio of absorption among the three filters. During calibration, a solution containing a known ethanol concentration (Ca) is analyzed by the instrument and normalized by dividing the known value (Ca) by the analyzed value resulting in the CAL. Furthermore, ratio calculations are determined based on the absorbance of ethanol at each of the three filters. These determinations, unique to ethanol, are compared to all subsequent analyses and must meet the criteria programmed in the DMT to qualify the sample as free of interfering substances. The starting detector voltages are not relevant so long as they are able to be zeroed at each of the three wavelengths, just as it had been during the calibration process.

During the predeployment testing of the DMT instruments in 2006-2009, there were observations made of certain instruments not performing well on interference testing. It was also noted that on some of these instruments, the detector voltage had drifted to levels above 300mV. An incorrect correlation was assumed that this higher detector voltage was the cause of the poor interference detection of the instruments. This phenomenon of high voltage and poor performance has proven to be coincidental, not causational. It was noted that on many of these instruments, the detector was replaced due to short term instability problems. A detector that is unstable in the short term would change detector voltage by 30mV or more over the time between the ambient zeroing and subsequent analysis. This would cause errors such as interference being detected when no interfering compounds were present, failing to detect an interfering compound that was present, filter won't zero error, calibration check errors and more. There is also documentation from this predeployment testing that shows instruments with high detector voltages successfully identifying interfering compounds.

DataMaster DMT 104509 was tested on 9/19/2011 against a solution of 0.01% vol/vol Acetone in 0.08 g/210L Ethanol. The detector voltage prior to the interference analysis was 0.029V at filter 1, 0.620V at filter 2 and 0.192V at filter 3 (see page 3). This instrument identified the interfering substance 10 out of 10 times (see page 4). Instrument 104509 was subsequently deployed to Ludlow Police Department. As observed on Routine Performance Check reports, the detector voltage steadily drifted to ~0.600V. The unit was removed from the field on 6/27/2012. On 6/28/12 the detector voltage was checked by performing a diagnostic test. This test indicated that the voltage for filter 1 was 0.711V, 1.233V for filter 2 and 0.823V for filter 3 (see page 5). The instrument was tested against a solution of 0.01% vol/vol Acetone in 0.08 g/210L Ethanol. The instrument was able to ambient zero prior to each sampling indicating that none of the three filter readings were beyond the limitations of the instrument. The unit again reported interference detected 10 out of 10 times (see page 6). Subsequent to the interference test, another diagnostic test was completed to show that the voltages had not changed significantly (see page 7). In reviewing the filter results for both interference tests, the filter 2 readings (the wavelength at which acetone has a stronger absorption) were not significantly different. This exemplifies the characteristics of the instrument: detector voltage over the long term has no impact on an instrument's ability to detect interfering compounds.

DIAGNOSTIC RESULT

DataMaster DMT:104509
Location:
Calibration Date:
Certification Date:
Installation Date:
Test Date: 09/19/2011
Test Time: 09:24:51

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VERSIONS
DMT: 1.00
PIC: 2.05
Modem: 2.1
Questions: 2.0

TEMPERATURES

Sample Chamber = 49.2°C
Breath Tube    = 46.6°C
Digital Sim    = 33.5°C

SETTINGS
Lamp Voltage   = 1.66 V
Cooler Voltage = 1.67 V
Bias Voltage   = 80 V
Chopper Freq   = 533 Hz

PUMP INFO
Flow Rate = 6.097 L/M

DETECTOR INFO
PUMP     ON          OFF
MAX(V)    0.0280      0.0307
MIN(V)    0.0266      0.0291

FILTER INFO
Filter 1    0.029  Zero = true
Filter 2    0.620  Zero = true
Filter 3    0.192  Zero = true

CALIBRATION CHECK
Xq  = 0.088  0.39%
```

ACCURACY & PRECISION REPORT

STATE OF VERMONT

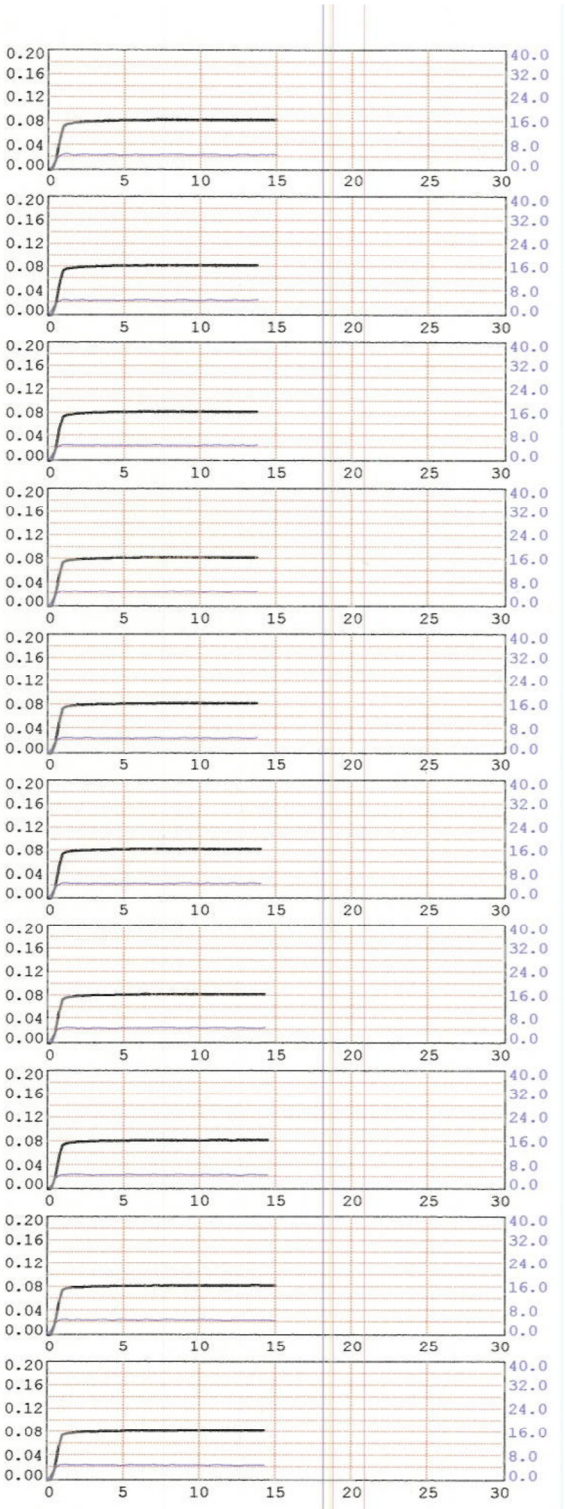
DataMater DMT: 104509

Date: 09/19/2011
Time: 10:40:50

SUPERVISOR NAME:
KIRK L KIMBALL

SOLUTION LOT #: 12-09-080A1
SOLUTION CONCENTRATION: 0.080

BLANK TEST	0.000	10:41
CALIBRATION CHECK	PASSED	10:41
Xq = 0.088 (0.39%)		
SIMULATOR VAPOR 33.7°C INTERFERENCE		10:42
X[1] = 0.0843 (-0.0069) (0.0011)		
SIMULATOR VAPOR 33.7°C INTERFERENCE		10:43
X[1] = 0.0840 (-0.0070) (0.0008)		
SIMULATOR VAPOR 33.7°C INTERFERENCE		10:44
X[1] = 0.0839 (-0.0071) (0.0008)		
SIMULATOR VAPOR 33.8°C INTERFERENCE		10:45
X[1] = 0.0840 (-0.0067) (0.0007)		
SIMULATOR VAPOR 33.7°C INTERFERENCE		10:46
X[1] = 0.0841 (-0.0066) (0.0005)		
SIMULATOR VAPOR 33.8°C INTERFERENCE		10:47
X[1] = 0.0843 (-0.0062) (0.0008)		
SIMULATOR VAPOR 33.7°C INTERFERENCE		10:48
X[1] = 0.0839 (-0.0070) (0.0006)		
SIMULATOR VAPOR 33.8°C INTERFERENCE		10:49
X[1] = 0.0835 (-0.0080) (0.0004)		
SIMULATOR VAPOR 33.7°C INTERFERENCE		10:50
X[1] = 0.0843 (-0.0068) (0.0007)		
SIMULATOR VAPOR 33.7°C INTERFERENCE		10:52
X[1] = 0.0839 (-0.0070) (0.0007)		
BLANK TEST	0.000	10:52



DMT Serial Number #104509 Page 1 of 1 06/28/2012 1:25 PM

DIAGNOSTIC RESULT

DataMaster DMT: 104509
Location: Ludlow PD
Calibration Date: 09/19/2011
Certification Date: 09/19/2011
Installation Date: 09/28/2011
Test Date: 06/28/2012
Test Time: 13:01:38

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VERSIONS
DMT: 1.01
PIC: 2.05
Modem: 2.2
Questions: 2.0

TEMPERATURES

Sample Chamber = 48.7°C
Breath Tube    = 45.6°C
Digital Sim    = 0.0°C

SETTINGS
Lamp Voltage   = 1.66 V
Cooler Voltage = 1.67 V
Bias Voltage   = 80 V
Chopper Freq   = 526 Hz

PUMP INFO
Flow Rate = 5.795 L/M

DETECTOR INFO
PUMP     ON         OFF
MAX(V)    0.7092     0.7128
MIN(V)    0.7071     0.7110

FILTER INFO
Filter 1   0.711  Zero = true
Filter 2   1.233  Zero = true
Filter 3   0.823  Zero = true

CALIBRATION CHECK
Xq  = 0.087  2.06%
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DMT Serial Number #104509 | Page 1 of 1 | 06/28/2012 1:02 PM

ACCURACY & PRECISION REPORT

STATE OF VERMONT

DataMater DMT: 104509
Location: Ludlow PD

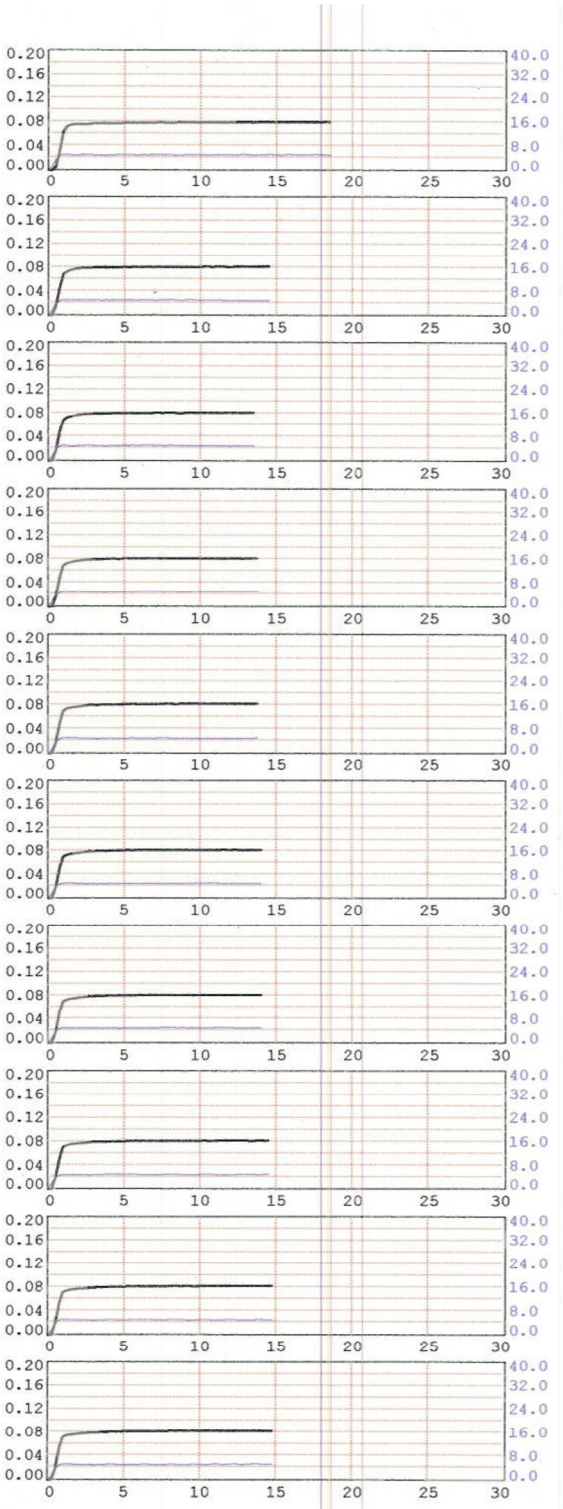
Date: 06/28/2012
Time: 13:10:20

SUPERVISOR NAME:
ALB ACETONE IN ETOH

SOLUTION LOT #: 12-79-08A1
SOLUTION CONCENTRATION: 0.079

BLANK TEST 0.000 13:11
CALIBRATION CHECK PASSED 13:11
Xq = 0.087 (1.67%)
SIMULATOR VAPOR 34.1°CINTERFERENCE 13:11
X[1] = 0.0814 (-0.0060) (-0.0002)
SIMULATOR VAPOR 34.0°CINTERFERENCE 13:12
X[1] = 0.0826 (-0.0058) (-0.0004)
SIMULATOR VAPOR 34.0°CINTERFERENCE 13:13
X[1] = 0.0826 (-0.0061) (-0.0006)
SIMULATOR VAPOR 34.0°CINTERFERENCE 13:15
X[1] = 0.0829 (-0.0060) (-0.0004)
SIMULATOR VAPOR 34.1°CINTERFERENCE 13:16
X[1] = 0.0832 (-0.0065) (-0.0002)
SIMULATOR VAPOR 34.1°CINTERFERENCE 13:17
X[1] = 0.0829 (-0.0066) (-0.0004)
SIMULATOR VAPOR 34.0°CINTERFERENCE 13:18
X[1] = 0.0829 (-0.0065) (-0.0001)
SIMULATOR VAPOR 34.0°CINTERFERENCE 13:19
X[1] = 0.0829 (-0.0063) (-0.0005)
SIMULATOR VAPOR 34.1°CINTERFERENCE 13:20
X[1] = 0.0830 (-0.0064) (-0.0002)
SIMULATOR VAPOR 34.0°CINTERFERENCE 13:21
X[1] = 0.0831 (-0.0061) (0.0001)
BLANK TEST 0.000 13:22

Temp 34.0
Thermometer # 101489856 (A)



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DIAGNOSTIC RESULT

DataMaster DMT: 104509
Location: Ludlow PD
Calibration Date: 09/19/2011
Certification Date: 09/19/2011
Installation Date: 09/28/2011
Test Date: 06/28/2012
Test Time: 13:25:33

```
VERSIONS
DMT: 1.01
PIC: 2.05
Modem: 2.2
Questions: 2.0

TEMPERATURES

Sample Chamber = 49.2°C
Breath Tube    = 46.2°C
Digital Sim    = 34.0°C

SETTINGS
Lamp Voltage   = 1.66 V
Cooler Voltage = 1.67 V
Bias Voltage   = 80 V
Chopper Freq   = 530 Hz

PUMP INFO
Flow Rate = 5.998 L/M

DETECTOR INFO
PUMP     ON         OFF
MAX(V)    0.6774     0.6799
MIN(V)    0.6758     0.6781

FILTER INFO
Filter 1   0.679  Zero = true
Filter 2   1.200  Zero = true
Filter 3   0.809  Zero = true

CALIBRATION CHECK
Xq  = 0.087  1.57%
```